

CLAIMS

What is claimed is:

1. A fuel injector comprising:
 - a valve housing,
 - a hollow stem depending from the housing,
 - at least one fuel nozzle assembly supported by the stem,
 - at least first and second staged fuel injection circuits in the fuel injector,
 - each of the first and second staged fuel injection circuits having first and second fuel injection points,
 - at least first and second fuel nozzle valves controllably connected to the first and second staged fuel injection circuits respectively,
 - the first and second fuel nozzle valves being operable to open at different first and second crack open pressures respectively,
 - the housing including a single fuel supply connector connected in fuel supply relationship with the first and second fuel nozzle valves and a single fuel signal connector connected in pressure supply relationship with the first and second fuel nozzle valves, and
 - the housing including a single fuel supply connector connected in fuel supply relationship with the first and second fuel nozzle valves and a single fuel signal connector connected in pressure supply relationship with the first and second fuel nozzle valves.
2. A fuel injector as claimed in Claim 1 further comprising the first injection point of the first

staged fuel injection circuit being a tip orifice in a fuel injector tip of a pilot nozzle of the fuel injector and the second fuel injection points of the second staged fuel injection circuits located in a main nozzle of each of the fuel injectors.

3. A fuel injector as claimed in Claim 2 wherein the main nozzle is annular and has radially extending spray orifices located at the second staged fuel injection circuits.

4. A fuel injector as claimed in Claim 3 further comprising:

internal fuel flow passages of the first and second staged fuel injection circuits extending through the annular main nozzle,

clockwise and counterclockwise extending annular legs extending circumferentially from at least a first one of the internal fuel flow passages through the main nozzle, and

the first injection points of the first staged fuel injection circuits located at spray orifices extending from the annular legs through at least one of the plates.

5. A fuel injector as claimed in Claim 4 wherein the annular legs have waves.

6. A fuel injector as claimed in Claim 5 wherein the waves are parallel.

7. A fuel injector as claimed in Claim 6 wherein the spray orifices are located in alternating ones of the first and second waves so as to be substantially aligned along a circle.

8. A fuel injector as claimed in Claim 2 further comprising:

- the first and second staged fuel injection circuits extending at least in part through a fuel injector conduit,

- the fuel injector conduit extending between the housing through the stem to the nozzle assembly,

- the fuel injector conduit comprising at least one feed strip having at least one bonded together pair of lengthwise extending plates,

- each of the plates having widthwise spaced apart and lengthwise extending parallel grooves, and

- the plates being bonded together such that opposing grooves in each of the plates are aligned forming internal fuel flow passages of the first and second staged fuel injection circuits through the length of the strip from an inlet end to an outlet end.

9. A fuel injector as claimed in Claim 8 further comprising:

- the internal fuel flow passages extending through the feed strip and the annular main nozzle,

- clockwise and counterclockwise extending annular legs extending circumferentially from at least a first one of the internal fuel flow passages through the main nozzle, and

- the first injection points of the first staged fuel injection circuits located at spray orifices extending from the annular legs through at least one of the plates.

10. A fuel injector as claimed in Claim 9 wherein the annular legs have waves.

11. A fuel injector as claimed in Claim 10 wherein the waves are parallel.

12. A fuel injector as claimed in Claim 11 wherein the spray orifices are located in alternating ones of the first and second waves so as to be substantially aligned along a circle.

13. A fuel injector comprising:
a valve housing,
a hollow stem depending from the housing,
at least one fuel nozzle assembly supported by the stem,
first, second, and third staged fuel injection circuits in the fuel injector,
the first, second, and third staged fuel injection circuits extending at least in part through a fuel injector conduit,
the fuel injector conduit extending between the housing through the stem to the nozzle assembly,
each of the first, second, and third staged fuel injection circuits having first, second, and third fuel injection points,
first, second, and third fuel nozzle valves controllably connected to the first, second, and third staged fuel injection circuits respectively,
the first, second, and third fuel nozzle valves being operable to open at different first, second, and third crack open pressures respectively,
the housing including a single fuel supply connector connected in fuel supply relationship with the first and second fuel nozzle valves and a single fuel signal connector connected in pressure supply relationship with the first and second fuel nozzle

valves,

the fuel injector conduit comprising a single feed strip having a single bonded together pair of lengthwise extending plates,

each of the plates having widthwise spaced apart and lengthwise extending parallel grooves, and

the plates being bonded together such that opposing grooves in each of the plates are aligned forming internal fuel flow passages of the first, second, and third staged fuel injection circuits through the length of the strip from an inlet end to an outlet end.

14. A fuel injector as claimed in Claim 13 further comprising:

the first staged fuel injection circuit being a pilot fuel circuit in an annular main nozzle,

the second staged fuel injection circuit being a main nozzle first fuel circuit in the main nozzle, and

the third staged fuel injection circuit being a main nozzle second fuel circuit in the main nozzle.

15. A fuel injector as claimed in Claim 14 further comprising:

the first fuel injection points of the first staged fuel injection circuits are tip orifices in fuel injector tips of pilot nozzles of the fuel injectors, and

the second and third fuel injection points are spray orifices in main nozzle first and second fuel circuits respectively in the main nozzles of the fuel injectors.

16. A fuel injector as claimed in Claim 15 further comprising further comprising the main nozzle fluidly connected to the outlet end of the feed strip and integrally formed with the feed strip from the bonded together pair of lengthwise extending plates.

17. A fuel injector as claimed in Claim 16 further comprising:

clockwise and counterclockwise extending annular legs extending circumferentially from at least one of the internal fuel flow passages in each of the main nozzle first and second fuel circuits in the annular main nozzle,

the clockwise and counterclockwise extending annular legs of the main nozzle first and second fuel circuits having parallel first and second waves respectively, and

the spray orifices are located in alternating ones of the first and second waves so as to be substantially aligned along a circle.